A Water Review Quarterly

Reclamation

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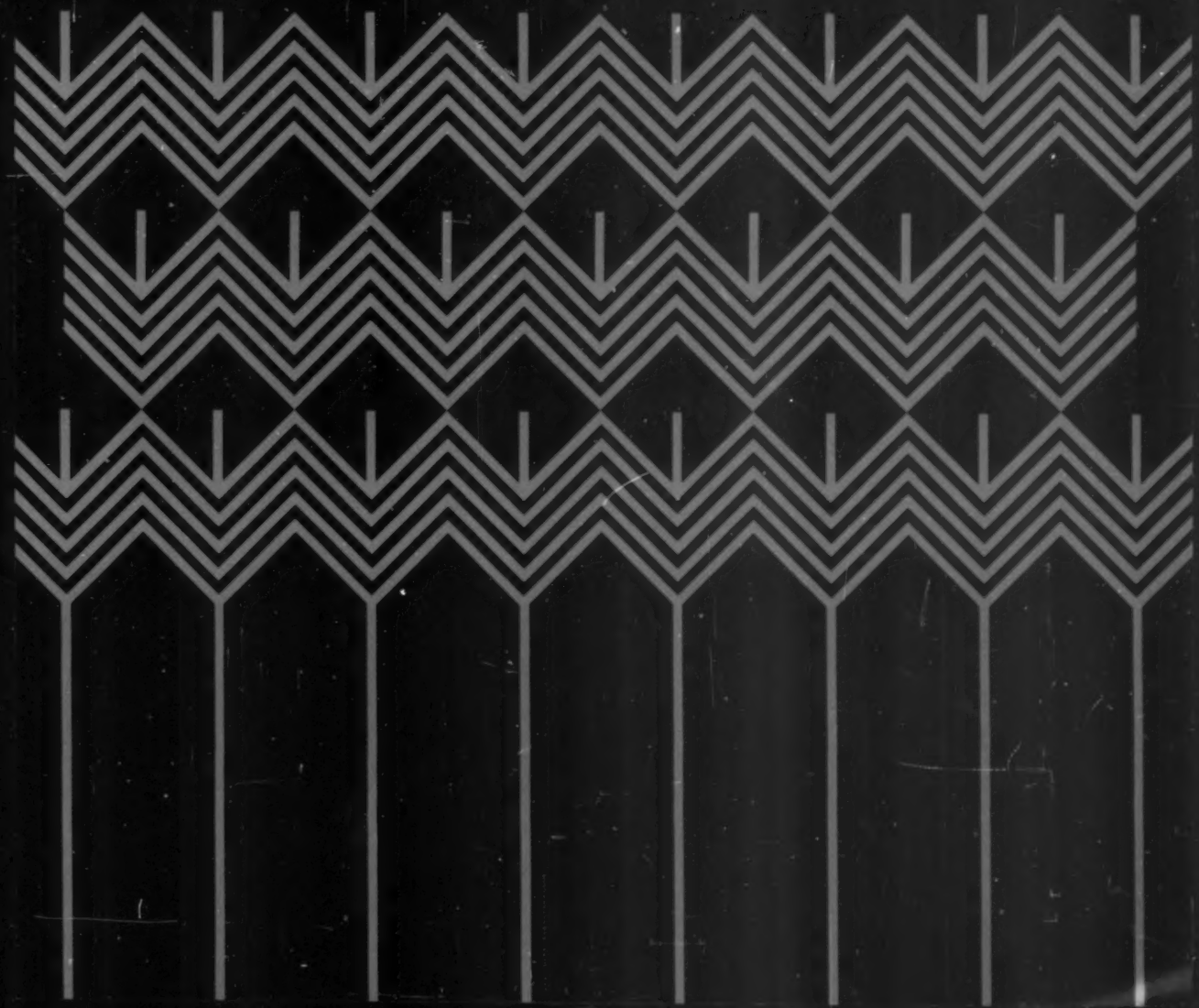

Reclamation

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Cecil D. Andrus, Secretary

Bureau of Reclamation
R. Keith Higginson
Commissioner

Editor
Carol A. White

Inquiries should be addressed to: Editor, *Reclamation Era*, Bureau of Reclamation, Code 140, Bldg. 67, P.O. Box 25007, Denver Federal Center, Denver, CO 80225

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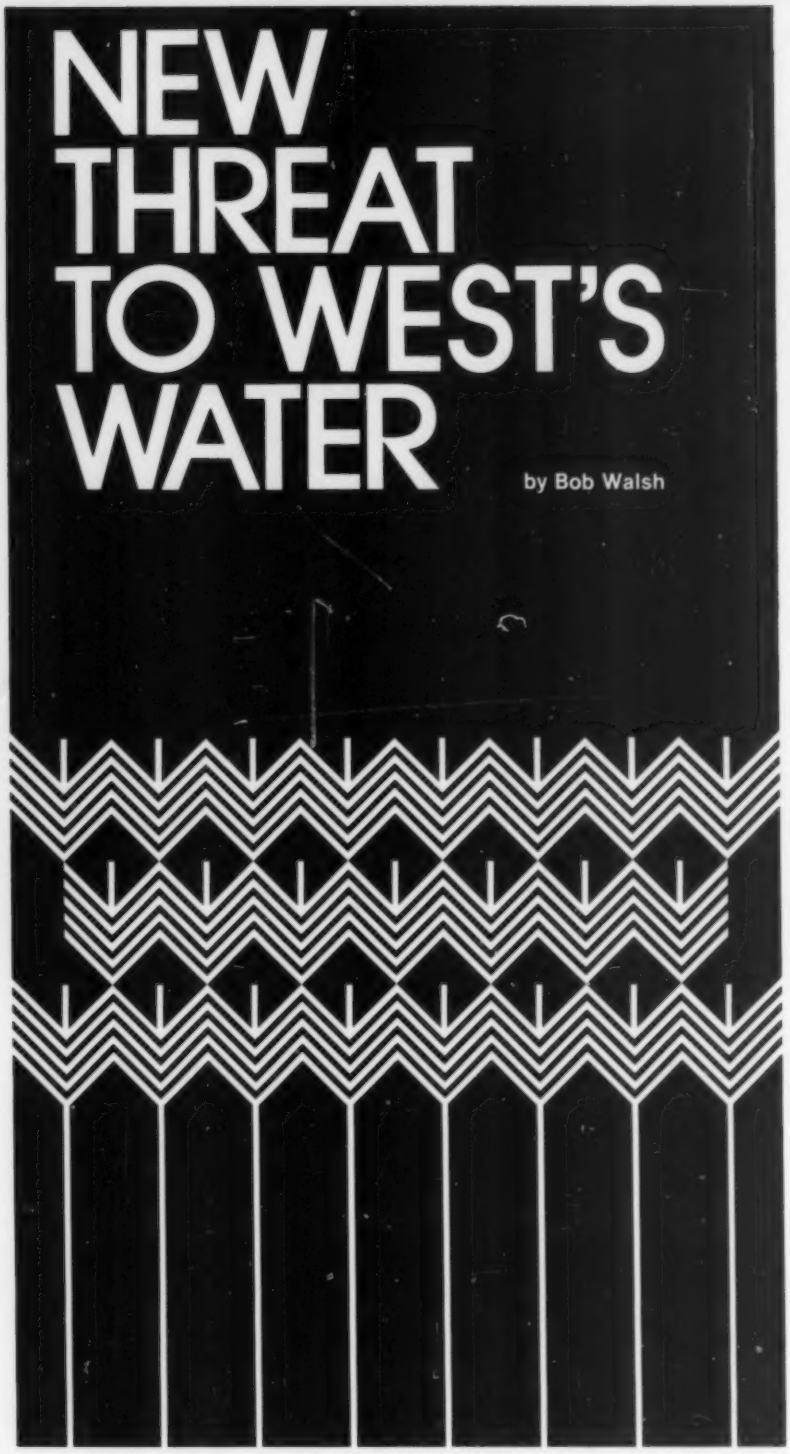
As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

NEW THREAT TO WEST'S WATER

by Bob Walsh



Fresh water in the water-short West is a critical resource. Many demands are made on this water. It is used to produce food and power, provide recreation, and fulfill municipal and industrial needs. The water also serves as a home for fish and other aquatic organisms, and as a resting habitat for migratory waterfowl. At times, there isn't enough water to satisfy the demands placed on it. Mother Nature often withholds the meager amount she normally gives to the Western States. Man's activities often pollute the water, and destroy its value for himself and for wildlife and vegetation. In the "good old days" ranchers and sheepmen even poisoned freshwater supplies to drive out homesteaders - and each other.

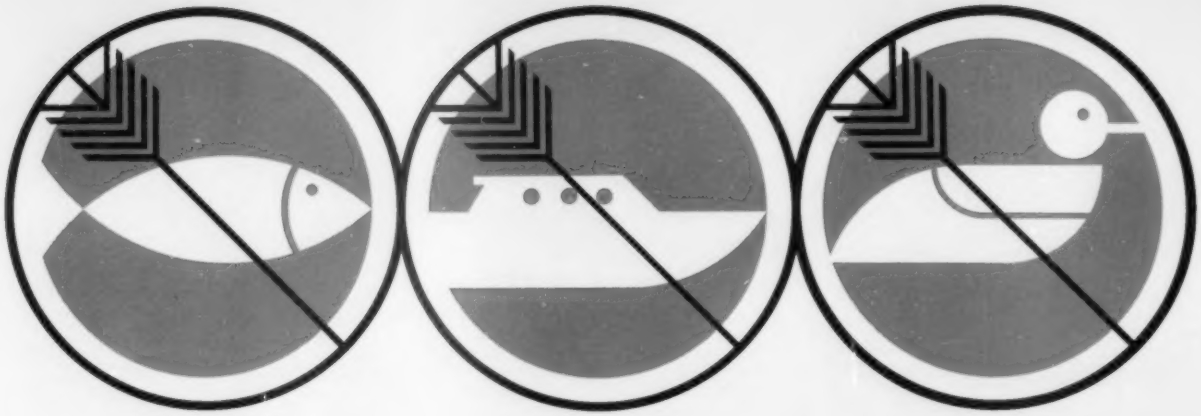
A new threat

Now, a new threat has emerged to create problems for the freshwater supplies of the West. The "villains"... two species of submerged aquatic weeds known as hydrilla and Eurasian watermilfoil.

Submerged aquatic plants are an important component of aquatic ecosystems. They supply oxygen to the water, and provide food and shelter for fish and other aquatic creatures. But when these plants become too abundant, or grow in the wrong

Bob Walsh, Writer-Editor, Public Affairs Service Center, Denver, Colo.

Photography by Gene Hertzog, Lower Colorado Region; Tennessee Valley Authority; Corps of Engineers; Fish and Wildlife Service.



place, they can change the aquatic ecosystem and alter the balance among competing organisms. They can seriously restrict the flow of water in rivers and canals, hamper navigation, and block the intakes to water treatment plants that supply domestic and industrial water. They tend to increase the siltation in rivers, lakes, and canals. They can severely curtail - even prevent - boating, fishing, swimming, or other recreational activities. And, as the plants die and decompose, they can deplete the oxygen supply in the water. Clearly, excessive growths of aquatic plants can create very undesirable conditions. Hydrilla and Eurasian watermilfoil are two such plants.

Hydrilla and Eurasian watermilfoil are perennial aquatic plants with fibrous root systems. Although they were thought to grow mainly in slow-moving waters less than 20 feet deep, both species have been discovered thriving in fast-moving water. Both plants grow very densely. Watermilfoil, where it reaches the surface, forms heavy mats of vegetation that are nearly impassable; the long, branching stems of hydrilla grow so close together they also are nearly impossible to penetrate, except by airboat.

Infest waterways

These noxious weeds reproduce very easily. Watermilfoil spreads when plant fragments become rooted in a new location. The fragments can be spread by wave action, winds, migratory waterfowl, running water, and human disturbance. Hydrilla, spread in much the same manner as watermilfoil, also reproduces through fragmentation. In addition, this weed can reproduce from tubers (similar to bulbs) that develop on the root system, and from turions - scaly buds that grow in the "V" formed where leaves or branches join the stem. Both plants die back in the fall and winter, and regrow and produce flowers during warmer weather.

Neither hydrilla nor Eurasian watermilfoil is native to North America. Eurasian watermilfoil was first noticed along the east coast of the United States in the late 1800's. Hydrilla was first discovered growing wild in the U.S. in Florida in the late 1960's. Since they were first discovered, these plants have infested thousands of acres of America's waterways. Eurasian watermilfoil is also found in Canada.

Eurasian watermilfoil, originally found in the Mideast, and hydrilla, believed to have originated in central Africa, were probably imported to this country as habitat and decoration for fish aquariums. Hydrilla, with its long, willowy green stem and small white flowers, and Eurasian watermilfoil, with a slightly pink stem and flowers that bloom a bright red, are both attractive plants. From the aquariums, the plants were probably dumped into a sewer system, river, shallow lake, or other water body. Once they became established and began to grow uncontrolled, their noxious characteristics quickly overshadowed their beauty.

Florida's Crystal River is heavily infested with hydrilla.

Control of these two aquatic weeds is difficult; they are strong competitors and, once they become established, eradication is nearly impossible. The State of Florida and Canada's British Columbia Province currently spend millions of dollars annually for only partial control of hydrilla and Eurasian watermilfoil, respectively. Two characteristics seem to account for the survivability of the plants. First, they adapt readily to a wide range of environmental conditions, including water temperature, available light, and type of soil. Secondly, there are no known naturally-occurring control agents on the North American continent, such as vegetarian fish or insects whose diets include hydrilla or Eurasian watermilfoil, to help control their growth.

To control hydrilla and Eurasian watermilfoil infestations, methods that are used to control other aquatic weeds are currently being employed. These methods include:

Mechanical—Mechanical control techniques involve the use of underwater mowers, rototillers, hydraulic dredges, and hydraulic jets that rake, pull, dig, or dredge the weeds. These methods provide immediate clearing of the problem area, but this clearing is generally only cosmetic and temporary. Mechanical methods generally eliminate only the stems and surface vegetation, the plants' roots are seldom disturbed — and this is where the primary area of growth occurs. This control technique may even stimulate additional growth by producing weed fragments which can be carried to previously uninfested areas to begin new colonies. Mechanical control methods are also expensive and time consuming, and they can have serious environmental impacts.

Boat-mounted spray rig can be used to spread herbicides.

Chemical—Herbicide application is a common method of aquatic weed control, although very few herbicides have been approved for use as aquatic weed control agents. Only those herbicides that have characteristics acceptable to the aquatic environment can be used.

Control methods somewhat effective

Approved aquatic herbicides are a relatively inexpensive control method when compared to other techniques. And, they have no adverse environmental impacts when properly used. They can generally be easily applied to problem areas by spray rigs mounted on boats, trucks, or helicopter, or carried by backpack.

Although herbicides are generally the most effective aquatic weed control method, they do have their drawbacks.

Treated waterways may have to be closed to humans and animals, and the water must often be kept off valuable croplands, at least temporarily. Also, since these herbicides generally dissipate rapidly, they affect only the plants growing at the time of application. Frequent reapplications of herbicide materials are necessary to control new growth.

New herbicide materials and methods of application are under development. But, the testing and pesticide registration procedure for these herbicides is a long, very costly process. It may be many years before additional, more effective herbicides can be made available for use as control agents.

Environmental Manipulation—These techniques are attempts at altering the weeds' beneficial environment. The use of plastic screens to inhibit

the growth of the plants, and water-level fluctuations or drawdown to expose the plants to drying, are examples of environmental manipulation techniques. These methods have, in certain instances, been somewhat effective. However, they also have their drawbacks.

Plastic screening, which involves covering waterway bottoms with gravel-covered plastic liners, is limited to small, shallow water bodies with gently sloping shorelines, and some beach areas. Maintenance of the screening has proven to be a difficult, almost impossible task. In addition, the screening material itself is expensive. To date, this method has not proven practical.

Drawdown also has distinct disadvantages. First, it is not always physically possible to lower the water level of a specific body of water. Secondly, when this method is used, care must be taken to minimize the effect of the drawdown on shore-spawning fish and other aquatic life. And thirdly, it is often impractical to lower the water level of storage reservoirs.

Integrated—Integrated control involves the use of two or more control techniques in combination. For example, a mechanical method could be combined with chemical agents to obtain more effective control than if either method was used alone.

Other, relatively untested methods are under investigation. These involve the use of biological control agents, such as herbivorous fish or insects, and bacteriological agents such as plant diseases. Biological or bacteriological agents may, in time, prove useful. For example, a vegetarian fish native to eastern

Asia, the white amur or "Asian grass carp," appears to be a particularly attractive biological control agent. This fish has been successfully introduced into various parts of the world to help control aquatic weed growth, and is currently being considered as a control agent in this country. However, any biological or bacteriological control agents must be proven environmentally safe before they can be used, and these investigations can take many years to complete.

As they spread across the continent, both hydrilla and Eurasian watermilfoil eventually infested water bodies on Reclamation projects. Their discovery is of great concern. If left untreated, the plants could seriously impair the water management functions the projects are designed to perform. If the

Impair water management

plants gain a foothold, merely controlling their growth at a given level could cost millions of dollars annually. And, if the plants are not treated and controlled now, they can be expected to spread to other water bodies throughout the West.

Within Reclamation's 17 Western State operating area, hydrilla has gained its strongest foothold in the Imperial Irrigation District's waterways in Southern California.

The weed was first discovered growing in the All-American Canal near Calexico, Calif., in 1977. In a 2-year span, it has

A fragment of hydrilla.

spread over 370 miles of the District's canal system. Already, the weed is exhibiting some of its noxious properties. Sheldon Reservoir, a 58-acre regulation and conservation reservoir which has only been in operation since 1977, is 80 percent covered with hydrilla. The water holding capacity of the reservoir has been reduced by 25 percent. Some of the District's canals have been so badly infested their carrying capacity has been reduced by 40 to 90 percent.

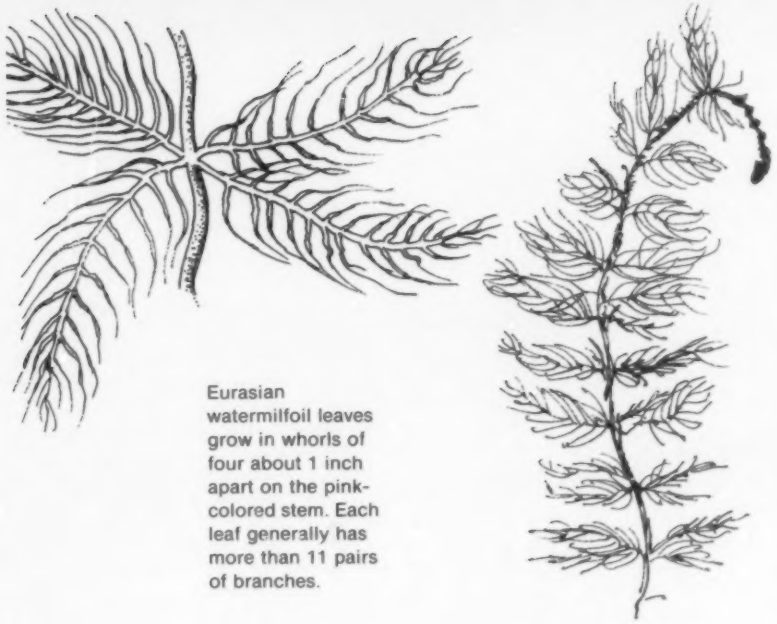
If this infestation is allowed to continue uncontrolled, it could seriously impair waterflow to municipalities, industry, and other irrigation districts. Recreation on lakes and waterways could become very difficult, even impossible. Flow restriction in infested waterways could cause increased flooding, with an attendant loss of property and life. The valuable cash crops grown on the fertile soils of the Imperial Valley could be seriously impacted. There is also concern that the weed will, if left uncontrolled, spread throughout the Imperial Valley and into the water systems of California, Arizona, and Mexico.

In recognition of the threat posed by hydrilla, local, State, and Federal agencies are now trying to develop a program to control this noxious weed in the Imperial Irrigation District.

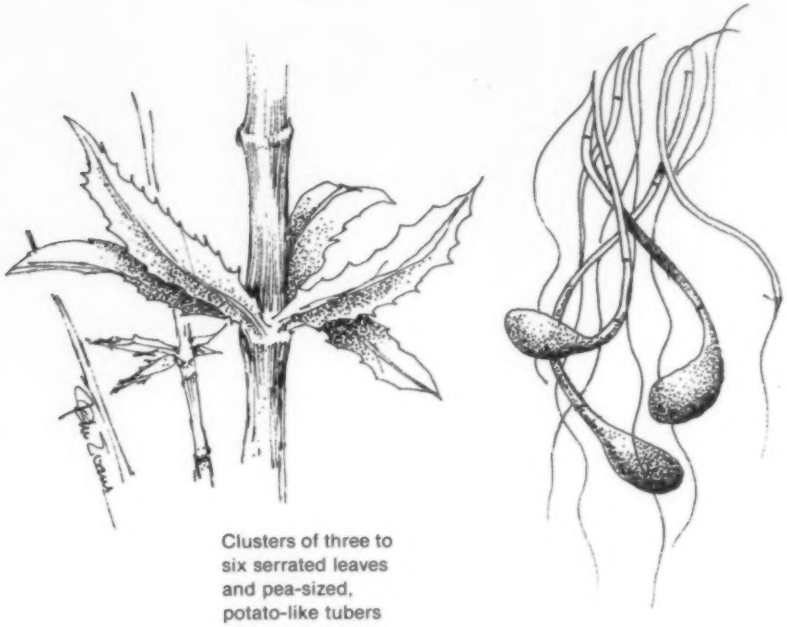
Eurasian watermilfoil is also well established in Reclamation's operational area. It is particularly evident in the Pacific Northwest. The State of Washington alone has 20 lakes or reservoirs that are infested with the weed. One of these is Banks Lake, on the Columbia Basin Project. A 400- to 600-acre infestation in this major irrigation reservoir is already limiting recreational use at the reservoir. The weed has also gained a foothold in other lakes on the Columbia Basin Project.

Weeds cover 80% of reservoir

The discovery of Eurasian watermilfoil in Columbia Basin reservoirs raises the possibility that it may also find its way into the Columbia River. If the watermilfoil becomes widespread along the Columbia River system, it would not only hamper recreation and water delivery, it has the potential to interfere with the operation of the hydroelectric plants that dot the river. For example, the maintenance costs of cleaning penstock intakes could rise very quickly. And, it doesn't take much imagination to envision the problems that would result if a 35-foot raft of watermilfoil found its way into a set of turbines.



Eurasian watermilfoil leaves grow in whorls of four about 1 inch apart on the pink-colored stem. Each leaf generally has more than 11 pairs of branches.



Clusters of three to six serrated leaves and pea-sized, potato-like tubers on thick "roots" are characteristic of Hydrilla.

Just how Eurasian watermilfoil was introduced to Washington State waters isn't certain. It may have been dumped from an aquarium, or perhaps transferred from out of state by the uncleaned boat of some recreationist. It might also be advancing into the State via the Okanogan River, which joins the Columbia River near the town of Rocky Butte, in north-central Washington.

Eurasian watermilfoil began colonization in Canada's Okanogan Lake sometime prior to 1970, and has progressed steadily down the Okanogan chain to Lake Osoyoos, on the U.S.-Canadian border, despite extensive control efforts by the Canadians. It is quite possible that the weed will spread down the Okanogan River into the Columbia. However, the province of British Columbia is making a major effort to prevent downstream spread by the use of screens at the lower end of the lake.

The proliferation of Eurasian watermilfoil in Washington State is not going unchallenged. Following the discovery of the weed in Banks Lake in 1977, Reclamation and the Corps of Engineers began a cooperative program to investigate methods for controlling the infestation in this and other Columbia Basin reservoirs. Efforts are also underway by Federal, State, and local entities to control the weed in other water bodies throughout the State.

During the fall of 1978, Banks Lake was drawn down to force fall-spawning kokanee salmon in the lake to lay their eggs at a lower level, thus providing the eggs and fry ample water cover during the spring, when the water level is naturally lowered by irrigation withdrawal. The drawdown was also expected to expose the watermilfoil, remov-

Herbicide being sprayed into an Imperial Irrigation District canal.

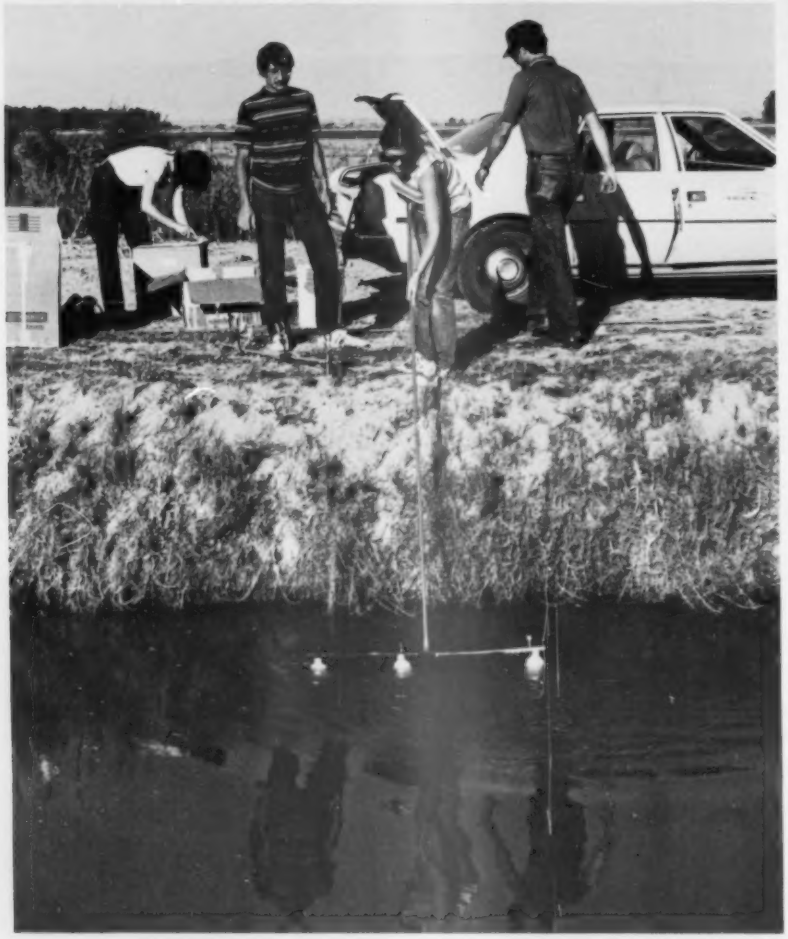
ing it from its life-sustaining water environment and exposing it to the elements to dry. However, a wetter than average fall caused less irrigation water withdrawal, and, therefore, less drawdown than was planned. As a result, the watermilfoil was not exposed as long as desired.

Clearly, there is a need to control the spread of both hydrilla and Eurasian watermilfoil. The effort will take the combined resources of local, State, and Federal entities, as well as a conscious effort on the part of the general public. Within the Bureau of Reclamation, a research effort aimed at developing and evaluating methods to control these pests with as little environmental impact as possible is underway. The program is coordinated with the ongoing research and development efforts of the Cooperative Aquatic Weed Research Program, a 30-year-old program involving Reclamation, the Department of Agriculture's Science and Education Administration, and the U.S. Fish and Wildlife Service.

Studies stress practical control

The program, expected to last several years, is being conducted by personnel of the Division of Research, located at the Engineering and Research Center in Denver, Colo. Laboratory and site specific field experiments will be performed to evaluate several control techniques for use on Reclamation projects. Studies and investigations will be conducted on:

- The effectiveness of available herbicides and the feasibility of using new or untested herbicides;



Water samples from treated canal determine effectiveness of herbicide.

• Controlled release herbicides that may be lethal to the weeds with only minimal adverse impact on desirable aquatic organisms;
• Chemicals that may herd fish and/or fishfood organisms out of the areas to be treated, thus reducing the chances of killing or harming non-target organisms;
• Environmental manipulation techniques such as complete dewatering of canals, reservoir drawdown, or management of nutrient levels and water temperature to retard plant growth; and
• Biological control agents such as herbivorous fish or naturally-occurring vegetation that will compete effectively with the weeds.

These studies will particularly stress the development of practical control methods integrating mechanical, chemical, biological, or environmental techniques. Finally, the studies will closely examine how operation and maintenance practices of a total system may contribute to or negate the proliferation of the weeds.

Fresh water - we need to utilize every available drop to the maximum extent practicable. Two noxious weeds - hydrilla and Eurasian watermilfoil - are threatening to seriously curtail the uses which man and animal alike may make of this valuable resource. In some instances, the weeds may encroach so severely on a water body they will limit even the amount of fresh water that is available for use. The people of the West - individuals, private organizations, State, local, and Federal governments - have worked together before to defeat other threats to their water supply; it will take the concerted efforts of all to meet this new challenge. ■

Federal and State Government agencies have spent millions of dollars attempting to prevent the spread of hydrilla and Eurasian watermilfoil. Individuals who use the western waters threatened by these aquatic plants can also be of vital help in controlling further infestation. Here's how you can help:

Recreationists
• Keep boats out of weed beds. The propellers fragment the weeds and allow them to reach new locations. The weeds can also damage marine engines.
• Remove all weeds from boats, motors, and trailers, fishing gear, and all other recreational equipment; dispose of them where they cannot reach water.
• Don't use water weeds in fish creels or boxes.
• Drain boat water tanks on grassy areas or other locations where the weeds cannot get into another water body or storm sewer.

Irrigators
• Notify your county extension agent if you find unfamiliar weeds in your stock watering ponds, ditches, or other bodies of water.
• Remove all weeds and weed fragments from equipment used to clear ditches and laterals.

Landowners
• Clean weeds from beach areas before they have a chance to root and become established.
• Check with local authorities before constructing docks or breakwaters. Protected areas allow these shallow water plants to become easily established.

Aquarium Owners
• Wrap aquarium plants in newspaper and dispose of them with the garbage.
• Dump aquarium water on the lawn or other location where it cannot get into a storm sewer or natural water body.

For additional information or plant identification, contact the nearest Bureau of Reclamation project office or other Federal or State office concerned with weed control or fisheries. ■

Environmental Education: A Step on the Involvement Ladder

by Diane L. Noennig

If you think one year ahead...plant a seed.
If you think ten years ahead...plant a tree.
If you think 100 years ahead...educate people.

The truth inherent in that philosophy has not changed in the hundreds of years since it was developed by the Chinese in the third century.

Today, the Bureau of Reclamation is applying that philosophy in the field of environmental education, a program aimed at making today's youth and tomorrow's adults more aware of the manner in which natural resources are managed.

Diane L. Noennig, Public Information Specialist, Upper Missouri Region, Billings, Mont.

Photography by Diane L. Noennig, Upper Missouri Region; Howard Paul, Engineering and Research Center, Denver, Colo.

Some people may be surprised to learn that the environmental education program we are familiar with today really had its roots in the tumultuous decade of the 1960's. The intense introspection that occurred during that period gave birth to new attitudes and values that challenged the old develop-and-expand philisophy which had existed for nearly 200 years.

Awareness of resource management

The introspection of the 1960's spawned a host of new movements in our society, one of which was environmentalism. Unlike most of the other philosophies of that period which gradually lost momentum and disappeared, environmentalism has continued to flourish and generate controversy. The reason for much of this controversy is that there are some organizations in the environmental movement that oppose any new development or any new growth.

People recognized the need to clean up our air, land, and water; after all, Spaceship Earth today contains all of those resources we will ever have.

However, some solutions which were offered threatened to close industries, drastically raise prices through enforcement of costly regulations, or lock up vast areas of the country to resource use. Seldom did those proposals address the question of economics as related to jobs, food supplies, or lifestyles. When they did, they were based upon the two most difficult and often demoralizing forms of persuasive appeals—fear and guilt.

Environment...ecology...preservation...conservation—all are words which became a call-to-arms for diverse factions of society. And there were many in the middle trying to understand the differing and usually conflicting theories of the opponents.

Teachers practice what they learn in the workshop.

Out of this need for an understanding of the way we interact with our environment, it became obvious that there was a requirement to educate people to the issues involved, and the Congress passed the Environmental Education Act of 1970.

Environmental education is not necessarily a new concept. It is, rather, a maturing and melding together of many concepts which have been in practice since 1891 when Wilbur Jackman, often called the father of nature study, published *Natural Study for the Common Schools*, a book on the theory of nature studies. Jackman later became Dean of the School of Education at the University of Chicago, and published the third yearbook of the National Society for the Study of Education, giving direction to nature education.

Theodore Roosevelt is recognized as one of the first Presidents concerned with the wise use and management of the Nation's natural resources. During his administration (1901-1909), voices were raised urging that schools should include conservation issues in their educational programs.

EE basic to public involvement

Conservation education first appeared in college programs during the early 1900's, but it was not until the 1920's that conservation education began to find its place in the public school systems. At this time, the Outdoor Education Movement also began stressing the acquisition of skills for the intelligent use of the outdoors. While many of these skills are related to recreation, they also supplement such school study areas as field science, and safety and health education.

With the passage of the 1970 Environmental Education Act giving the U.S. Office of Education responsibility and funds to assist the State departments of education in implementing environmental education programs, and also giving authority to other Federal agencies to assist in implementing these programs, many States passed laws requiring environmental education in grades kindergarten through 12. A number of Federal agencies with natural resource management responsibilities have been involved in environmental education for many years—among them the Department of Agriculture's Forest Service and Soil Conservation Service, and the Department of the Interior's Bureau of Land Management, National Park Service, and Fish and Wildlife Service.

On October 10, 1978, Commissioner of Reclamation R. Keith Higginson approved the policy guidelines for a Bureau-wide Environmental Education program. The program is designed to provide educational experiences to the public to help develop an awareness of

the multiple uses and conservation of the Nation's water resources. To accomplish this, Reclamation plans:

1. Training for Bureau personnel actively involved in the program;
2. Full cooperation, on a cost-sharing basis, with Federal and State agencies, school districts, colleges, universities, business and industry, special-interest groups and others responsible for and interested in environmental education;
3. Teacher training on an interagency basis in the broadened area of water resource management;
4. Cooperation with State education departments, public agencies and organizations to further a joint program effort;
5. Development of a variety of resource materials to illustrate water management principles and conservation;
6. Cooperative participation in curriculum development with educational authorities in integrating the principles of water resource management into established curriculum at all grade levels;
7. Coordination with other Reclamation programs, where an environmental emphasis exists, to prevent duplication of effort;
8. Support acquisition and utilization of land areas and facilities for environmental study areas;
9. Information programs for people other than educators, to heighten awareness in water-related environmental concerns;
10. Media support to inform the public in general, and educators in particular, of the expertise available in the Bureau of Reclamation on water resources, including information and materials related to environmental education activities;
11. Evaluation of its environmental education program, on both a short-term and long-term basis.

As one of the first steps in implementing Reclamation's program, an environmental education training conference was conducted in May 1979 for Reclamation personnel from all the regions and the Washington Office. The three-day conference, which was held in Denver, dealt with the many approaches to the environmental education program and methods for cooperating with other agencies which have responsibilities in such a program as well as developing a program for Reclamation.

EE training conference held

One day was devoted to communication techniques and values clarification exercises—two important skills a person must possess when dealing with a subject as impor-

Vern Fridley from Forest Service discusses their environmental education program.

tant and potentially emotional as environmental issues can be. The participants also worked on "back-home action plans" designed to clarify procedures to implement the various segments of the *Reclamation Instructions* on Environmental Education.

Education is process, not product

Environmental education is basic to implementation of a sound public involvement program on natural resource management. The public is demonstrating an increased desire to share in the decision-making processes concerning the management of the Nation's natural resources.

Environmental education serves as a tool to assist concerned citizens in understanding issues, as well as providing the information needed to help them make meaningful input into those decision-making processes.

Pam Domme, Kansas Reclamation Office, records her team's answers.

Citizens make choices about the use and management of natural resources in many ways. For example, they vote, decide on a lifestyle, choose a career, and help draft laws. Since natural resources are the basis for human existence, individual choices have a profound influence on the human condition. Therefore, knowledge and understanding relative to these resources and their use and management is essential for wise decisions.

How should an effective environmental education program work?

Education itself is a process, not a product. Yet, most educational programs are geared toward teaching people what to think, rather than how to think. The traditional approach to the teaching of environmental matters has been for the teacher to become knowledgeable, and then convey this information to the student through lectures. Students wishing good grades then recite this information back to the teacher. This process has not proven effective in

Environmental Education is many concepts

stimulating sustained interest in environmental matters, or in giving skills conducive to the development of an environmentally literate citizenry.

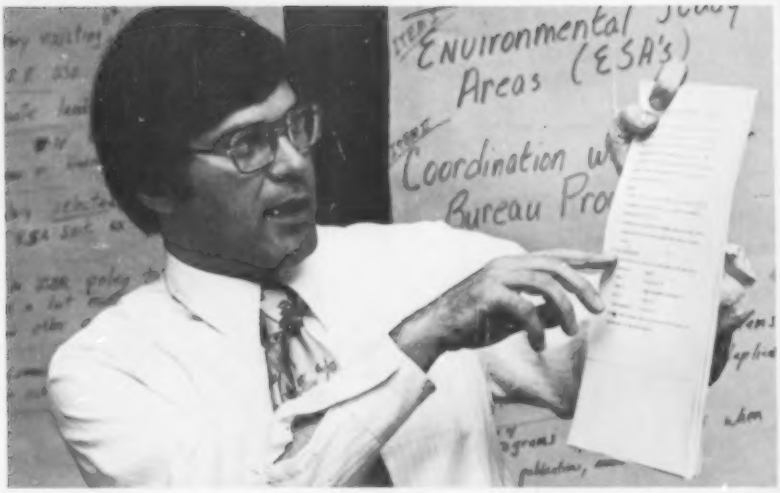
Reclamation's environmental education program will strive for the best and most effective methods of assisting educators in integrating water resource information into their environmental education curriculum.

There are many avenues open to achieve this goal. But one thought must remain paramount: while environmental education is associated with the biophysical environment, it is ultimately concerned with Man. We educate people, not environments.

Environmental education, of necessity, deals with personal values and attitudes. Because these attitudes can vary so widely, environmental educators stress that the teacher's role is not to lecture about the environment, but to assist students in acquiring information relevant to the decision-making processes. The student, whether in the primary grades or in adult education, needs to be able to recognize the values of others as well as his own personal opinions, to weigh alternatives, to communicate about personal choices, and to be aware of the ways these decisions may be made known to the proper authority.

The Bureau of Reclamation will help sponsor and will participate in teacher training workshops, in-service training involving water resources, and planning individual water units of instruction by teachers.

Gary Severson of Forest Service makes a point.



(Left to right) Robert Green, Wayne Hawk, Carlos Whiting, and Paul Strauss work as a team during a brain-storming session.

Hach water testing kit provides hands-on experience.

Reclamation employees from many disciplines can serve in an advisory capacity to teachers and educational councils to develop materials and curriculum guides on the multiple uses of water, such as irrigation, municipal and industrial, hydroelectric generation, recreation, and fish and wildlife enhancement.

The Bureau of Reclamation has entered into a contract, along with the Western States Water Council, with an organization called Water & Man, Inc., which will develop water-related curriculum, train teachers in its use, pilot test the new curriculum in schools throughout the West, and eventually make it available to interested school systems throughout the Nation. Water & Man, Inc., will draw together individuals from many special interest areas to assist in the development of this curriculum, including State and Federal resource agency technicians and scientists, and representatives from environmental organizations, water development organizations, and industry.

In addition, Reclamation will be working closely with other Federal and State agencies, including the State departments of education. All activities involving the development of educational materials on water management will be coordinated with educators and the State education departments to assure that these materials are usable instructional units.

Cooperation between Government, schools, and businesses

The Lower Missouri and Upper Colorado Regions of the Bureau of Reclamation, headquartered in Denver and Salt Lake City, respectively, have also entered into a similar contract with the Colorado Water Congress for the development of a curriculum called the Captain Hydro Water Conservation Program. These regions have been able to assist in expanding the Captain Hydro Program far beyond just the idea of saving or conserving water so that it relates more closely to the everyday importance and impact of water on people in the West.

The Bureau of Reclamation, as a Federal agency, will also be looking for opportunities to cooperate with local school districts in making environmental education study areas available on Reclamation project lands.

It is becoming obvious that increasingly diverse demands will be made on the Nation's land and water resources. Secretary of the Interior Cecil D. Andrus has recommended to President Carter that the Federal Government take the lead in fostering water conservation, and that the cornerstone of future water policy must rely upon the wise management and conservation of our national water resources.

Fourth graders at at environmental education study area near Billings, Mont. Blindfolds encourage the use of senses other than sight.

Public involvement and environmental education will not be a panacea for all the resource questions the Nation will face in the years ahead, but both programs allow agencies such as the Bureau of Reclamation to better equip the public with background information so as to participate in the decision-making processes of their local, State and Federal governments. This will help provide the two-way communication necessary between the public and the natural resource planners and managers to insure the wise use and conservation of the Nation's natural resources. ■

Fourth graders doing soil studies at a study area near Billings, Mont.

Small Hydro: Part of the Energy Answer

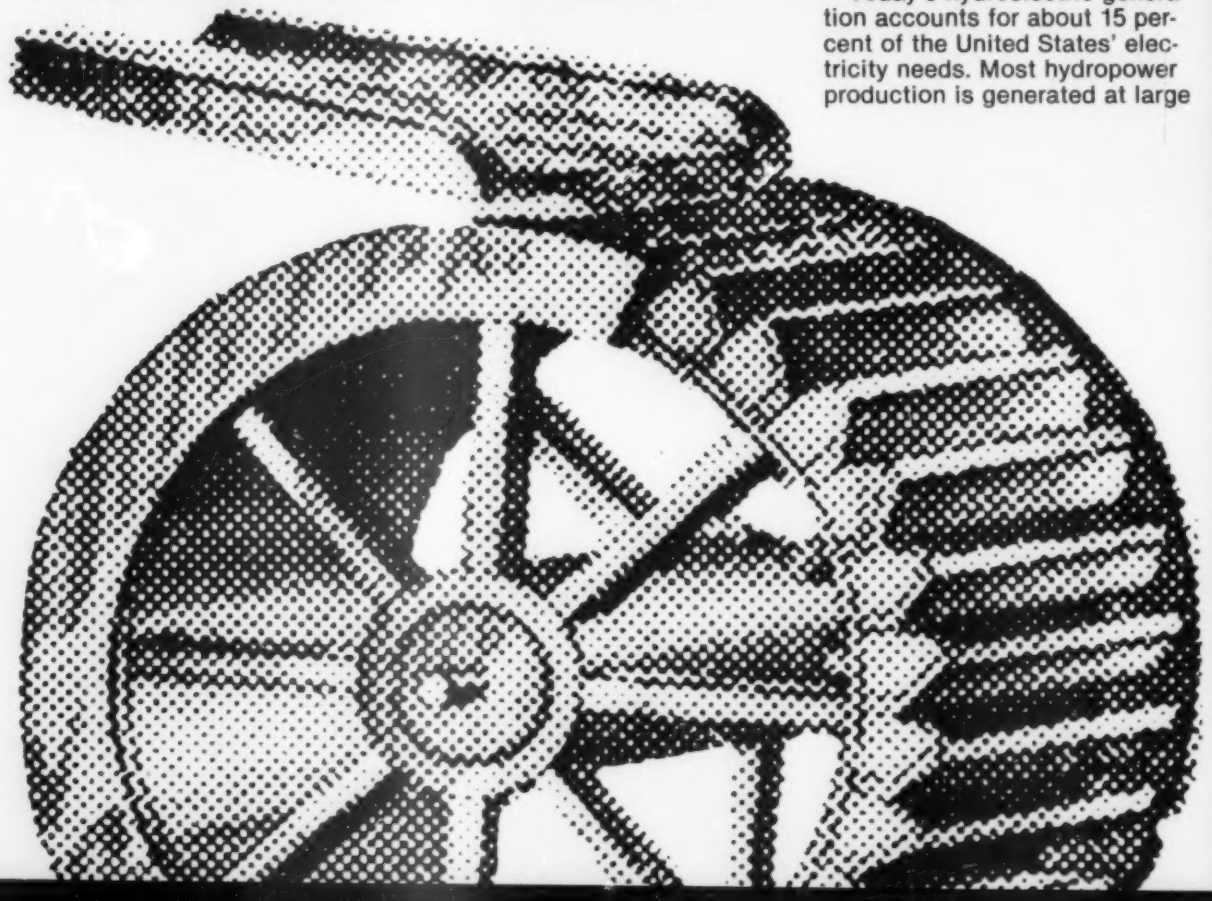
by Greg Luft

Low-head hydropower is an obsolete technology whose time has not yet come. But, that time seems to be rapidly approaching.

United States Government agencies and private industries are once again beginning to explore the potential of low-head hydropower dams (those with a water drop of 65 feet or less).

As early as the 1700's, Americans recognized the advantages of low-head power and used it extensively. As a matter of fact, from the time the first water-powered sawmill-gristmill was installed at Fair Haven, Vt., in 1793, to 1882 when the first low-head hydroelectric powerplants were installed at New York City and Appleton, Wisc., water power was our most important single power source. It accounted for over 40 percent of the Nation's electric power by the early 1900's.

Today's hydroelectric generation accounts for about 15 percent of the United States' electricity needs. Most hydropower production is generated at large



dams such as Hoover in Arizona and Grand Coulee in Washington State.

Although one of these dams produces much greater amounts of electricity at a much smaller cost than one low-head dam, their number has been limited due to environmental and social concerns as well as a lack of available sites. In contrast, there are literally thousands of small dams and other water-control structures such as canal drops, already in existence where a small generating plant could be installed.

Other considerations favoring low-head power producing dams are the rising prices of fossil fuels, which will continue to escalate as energy demands increase and fuel supplies decrease, as well as the environmental effects of the pollution caused by burning fossil fuels. At the same time, water which is used to power hydroelectric generators is free, renewable, and non-polluting.

Today the United States is probably the most advanced nation in the world in the production of hydropower from large dams (high head). In contrast, low-head hydropower technology is highly developed in Europe, especially in France, Switzerland, Germany, and the Soviet Union.

Greg Luft, Student Writer-Editor Trainee from Colorado State University, Public Affairs Service Center, Denver, Colo.

Photography by Gene Hertzog, Lower Colorado Region; Bert Holmes, Pacific Northwest Region.

Small drops on canals like this one on the Coachella Canal in California can be used to produce hydroelectric power.

Recent U.S. studies have shown that potential hydropower production at 49,000 existing sites would contribute as much as 54,000 megawatts of power. Nearly half of the 54,000 megawatts would be produced at low-head dams.

Hydroelectric... free, renewable, non-polluting

To encourage the reincarnation of low-head hydroelectric power in the United States, the Bureau of Reclamation along with the Department of Energy (DOE) and the U.S. Army Corps of Engineers, is exploring the development potential of low-head power. One of the first studies completed by the Bureau of Reclamation was the "Western Energy Expansion Study" (WEES). This study, completed in 1977, involved a reevaluation of over 100 hydroelectric sites under today's criteria of economic, environmental, and social concerns. It also addressed the uprating of the capacity of existing hydroelectric powerplants and the feasibility of testing, developing, and using alternative energy sources, such as solar, wind, and geothermal.

Reclamation now has underway over 30 investigations of specific hydropower sites to test their feasibility for development and marketability. These 30 sites are believed to have a potential of supplying over 13,000 megawatts of power. Six of the 30 sites are on the Columbia Basin Project in Washington State.

As a result of the WEES, a special study called the "Low-Head Hydroelectric Evaluation and Inventory" is now underway by Reclamation. This 3-year study began in 1979 and will cost almost $1 million. By careful study of sites throughout the 17 Western States, the evaluation and inventory will identify potential low-head hydroelectric developments at new dams, existing dams, and canal drops. This study is being carried out in close cooperation with the U.S. Army Corps of Engineers.

The Bureau of Reclamation is also working with the Department of Energy, which has an extensive program designed to promote the development of low-head hydroelectric power development.

Close cooperation with other agencies

As a part of this cooperation, Reclamation is currently performing five special DOE-funded studies to assist in this effort. These include:

1. A study of the marketability of low-head hydroelectric power;
2. A study to investigate the lower practical limits of low-head installation (how small can a low-head plant be and still be considered functional?);
3. A study of potential cost savings through standardization of inlet and outlet designs for low-head hydroelectric plants;
4. A study of the effects on power system operation from development of low-head plants;
5. A study of fish mortality caused by the passage of fish through low-head turbines. The National Marine Fisheries Service in the Department of Commerce is also cooperating in the latter study.

All of these studies are considering factors such as cost effectiveness in determining the feasibility of lowhead generation, and are contributing to the momentum for expansion of low-head power.

Low-head hydropower has many advantages, but experts agree it is only a portion of the ultimate solution to our energy problems. ■

Main Canal on the Columbia Basin Project. Coulee City is on the right.

Equipment for a small hydro powerplant could be installed at regulating structures.

A feeder canal on the Columbia Basin Project.

no reason to die

by J. Hunter Holloway

(Editor's Note: The author is a director of the National Association for Search and Rescue, and is a search-rescue mission coordinator for the State of Colorado.)

I first met Bob Whitmore while I was a reporter for the Associated Press. It was in 1970 and he was seated at the head of a wooden table in one of Denver's favorite eateries. It was a dark but regal place, where one might expect a Celtic Lord to pause and stretch tales over a hot ale. He was engrossed in vigorous conversation with a half-dozen others. They listened intently as he punctuated each statement with a thrust of his red beard and a flourished fist.

"There is no reason," he said, "for a man or woman to die in the wilderness."

Others at the table nodded in agreement. Bob, for the first time, spotted me and my button-down shirt headed toward him. I had arranged to meet him to discuss the possibility of accompanying him and his party on their next excursion into the wilderness to get a story. In my opinion though, the idea of spending a week in the Rocky Mountains in the dead of winter with no equipment, food supplias, or other support was crazy at best.

As I approached, Bob stood with such quickness that the silver-mounted bear claw at his throat jumped over his shoulder. "You're that reporter—the one who told me I was crazy," he said with a discernable smile, but with ample volume to be heard throughout the room.

Wilderness excursion

"Join us. If you want to come along, you'd better get to know these people. We're going to find out once and for all if a man lost in the high country can survive, regardless of his background."

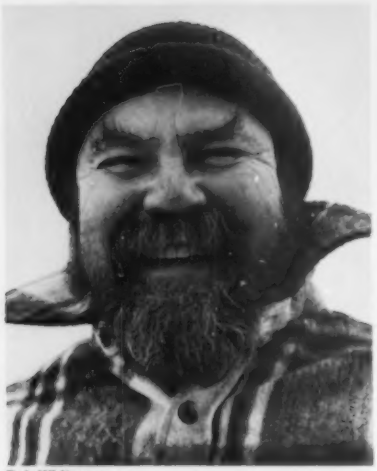
During the next two hours, I learned that I was as crazy as the rest. We had volunteered to participate in a November survival exercise near timberline in the Mummy Range northwest of Denver. Eight of us spent five days up there, living off our wits, the contents of our pockets, our normal outdoor clothing, and the fellowship Bob instilled. We survived—just as Bob Whitmore had said we would, and it was fun.

If you would like to learn how to survive an emergency high in the mountains, in the desert, or anywhere—follow the leader. Look up Bob Whitmore—if you can catch him.

Whitmore is one of the Nation's foremost professors in survival education. On a weekday he might be found in his office at the Bureau of Reclamation's Engineering and Research Center in Denver, where he issues construction specifications.

J. Hunter Holloway, Media Relations Officer, Public Affairs Service Center, Denver, Colo.

Bob Pauline, Bureau Photographic Coordinator, Public Affairs Service Center, Denver, Colo.



Bob Whitmore

Students in survival education class group for start of practical experience.

But, if it's an evening or weekend, chances are he's off talking to a class about wilderness survival. Or, he's got a group of cross-country skiers tucked snugly away in a snowdrift during a wild winter storm. Or, he could be in New Mexico, teaching classes to the Navajo Indians in Shiprock, as he did for four days in January.

The Navajo Tribal Council caught up with Bob in Farmington, N. Mex., after a Navajo sat in on a class Bob was teaching for the Four Corners Search and Rescue Team. The association eventually developed into a course for the Navajo's law enforcement personnel and several other tribal members. As usual, the class included two days in wild and rugged country, practicing what Bob had preached.

Whitmore believes that any of us, regardless of our experience, schooling, or background, can be relatively safe and comfortable when thrown into a wilderness environment. And, he has proven it time and again.

He joined the Bureau of Reclamation in 1953, and found his avocation during the mid-1960's while serving as a volunteer instructor in Colorado's Hunter Safety Program. "While teaching safety to hunters," he says, "we kept hearing about outdoorsmen, hikers, and the like—people who should know the outdoors—perishing in the wilds. Yet others, who knew nothing of the wilderness, would come through an ordeal unscathed."

Expert in survival

"In each case," he says, "the one variable I could find was the individual's attitude. Those who used their heads, lived. Those who didn't, died. It wasn't so much what they knew, but how they used the knowledge they had."

"It would be nice to have just completed a shopping tour in Abercrombie & Fitch before you became lost, stranded, or stuck in a crashed aircraft. Unfortunately, we rarely plan for the unexpected and we are not equipped with super-effective clothing, food, and other niceties," he says. "Very frequently, we can survive until help arrives by using our intelligence and what we happen to have with us."

With that theme in mind, Whitmore established the Wilderness Institute of Survival Education (WISE) in 1970. Demand for the group's lectures grew. The talks by members became more and more frequent. The WISE program has settled in on a blend of lecture, practical discussions, and experience.

Bob and his colleagues, including several other Reclamation employees, were sought out by the National Rifle Association (NRA) and by the Boy Scouts of America to structure new and innovative survival education programs. These have matured into curriculums offered by an NRA facility near Raton and a training program for the staff of Philmont Scout Ranch, both in northern New Mexico.

Reclamation field offices, other government agencies, and

Whitmore gives first assignment: "Build a snow cave..."

Whitmore (l.) supervises digging of snow cave.

private organizations have requested the assistance of WISE to train their personnel, particularly those who because of their work are exposed to wilderness hazards.

These have included special agents of the FBI, emergency personnel from several States, employees of the U.S. Geological Survey, Bureau of Mines, Department of Agriculture, the National Guard, and several rescue teams.

The emphasis in survival education is on rational thought, the avoidance of panic, and full utilization of one's resources. That portion of Bob's class is called "Psychology of Survival." But, he and his colleagues also explain the importance of water, shelter, clothing, and signalling. They will tell you how to find water and food, protect yourself against frostbite, sunburn, snow blindness, and the dangers of heat (hyperthermia) and cold (hypothermia).

Ted Brooks, Western Colorado Area Safety Manager in Reclamation's office at Montrose, describes Whitmore as "a very effective, practical instructor. Whitmore builds confidence. Once he spends five minutes in a classroom, it flows."

About three years ago, a helicopter chartered by the Bureau crashed during a ground blizzard on 10,000-foot Grand Mesa, north of Montrose. The pilot and a Reclamation observer, who had been through Whitmore's class, escaped serious injury but were stranded in deep, blowing snow and cold far from civilization.

Use your head and live

"When found hours later," says Brooks, "the two had a fire going and were building one of Bob's snow caves for shelter from the storm. They were in good shape." ■

Whitmore points out the strong and weak points of snow.

A collapsible shovel is ideal for digging in close quarters.

Buckskin Mountain Hole-Through

Shortly after noon, May 25, 1979, a huge tunnel boring machine known as a "mole" chewed its way through the final inches of rock and soil on the western flank of the Buckskin Mountains, about 20 miles north of Parker, Ariz. "Hole-through" of the Buckskin Mountains Tunnel came almost 3 years to the day after the "mole" began boring. The 6.8-mile-long tunnel was begun on May 14, 1976.

The event was an important milestone in the construction progress of the Bureau of Reclamation's Central Arizona Project, which will deliver Colorado River water to the Phoenix and Tucson areas. The first water is scheduled to flow in 1985.

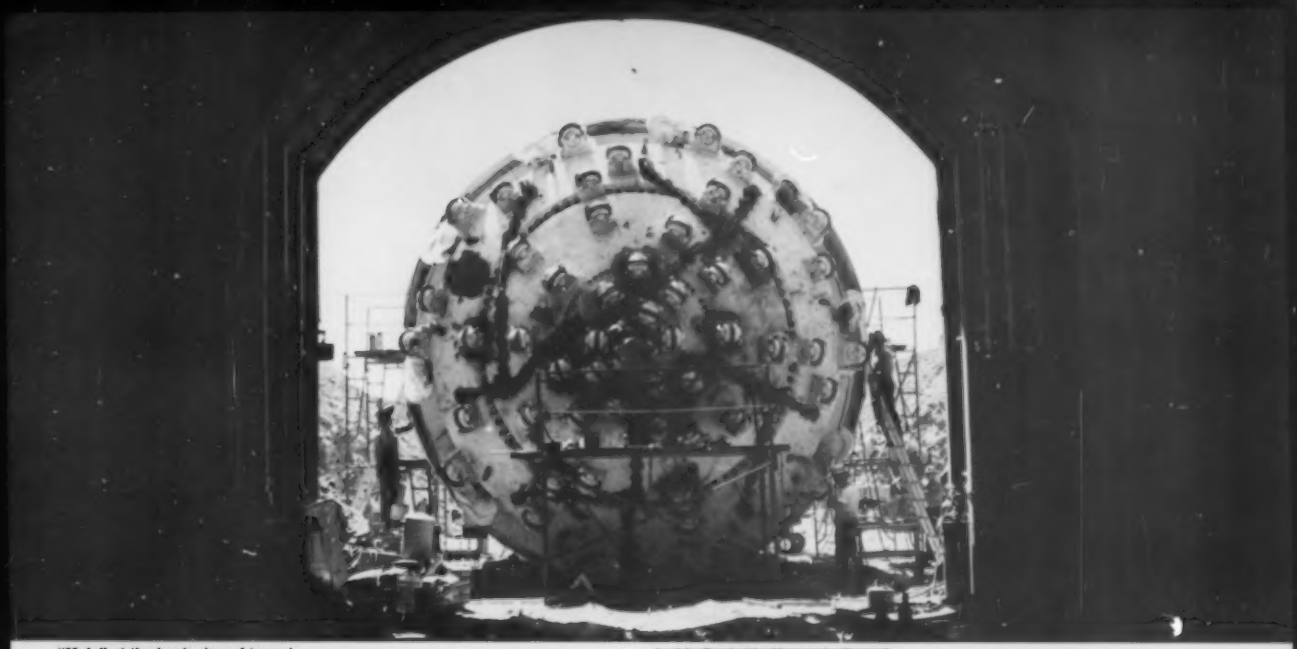
The tunnel connects the eastern and western slopes of the Buckskin Mountains. It is 22 feet in diameter—about 2½ stories high—and will convey up to 3,000 cubic feet of water per second. It is lined with over 28,000 precast concrete segments, each weighing about 3½ tons. The Buckskin Mountains Tunnel is the first such segmented tunnel constructed by Reclamation.

The water will be pumped 800 feet from Lake Havasu to the west portal of the Buckskin Mountains Tunnel. From there, it will flow along the 192-mile-long Granite Reef Aqueduct to Phoenix. Once it reaches Phoenix, the water will flow south in the Salt-Gila Aqueduct to communities and agricultural areas in Maricopa and Pinal Counties, and to the Tucson Aqueduct, which will carry it about 60 miles to Tucson.

The Central Arizona Project, begun in 1973, was prompted by the critical shortage of water facing Arizona and its people in the future. The basic plan calls for a system of pumping plants and aqueducts ultimately delivering an annual average of 1.2 million acre-feet of Colorado River water for agricultural and municipal uses. Supplemental irrigation water will be provided to nearly 1 million acres of Indian and privately-owned lands. The metropolitan areas of Phoenix and Tucson will receive about 500,000 acre-feet of water. Flood control, outdoor recreation, fish and wildlife conservation, and sediment control will also be provided. ■

Photography by J. Madrigal, Jr. and Gene Hertzog, Lower Colorado Region.

Spectators view cutterhead of "mole" close up after hole-through.



"Mole" at the beginning of tunnel.

Inside Buckskin Mountain Tunnel.

The Engineering and Research Center:

The Beginning

by Kim R. Bell

July 20, 1950—Colorado Governor Walter Johnson, Denver Mayor Quigg Newton, Colorado Congressmen Wayne Aspinall and John Maraslis, and Reclamation Chief Engineer L. N. McClellan were among a throng of high-ranking State and Federal officials and others listening as Reclamation Commissioner Michael Straus read President Harry S. Truman's letter.

"The dedication of the Reclamation Engineering Center at Denver, Colorado is an event worthy of the widest recognition...In this Center, you have concentrated the wide range of scientific skills and experience and are providing the engineering teamwork required to assure the fullest and most economical development of our Western irrigation, hydroelectric power, and related water resources."

Truman's words highlighted the official beginning of the Engineering Center, and kicked off a 2-day celebration that attracted 40,000 visitors according to official estimates. The dedication was sponsored by the city of Denver, and the entire metro area was caught up in the event. Leading Denver department stores featured window displays of the Bureau's work. Models and photographs were displayed in city hall. It was indeed a major happening in Reclamation history.

The dedication of Reclamation's Engineering Center marked the completion of initial installation of facilities at the Denver Federal Center, a 4-year project begun in late 1946. Before 1946, the Engineering Center had been housed in the U.S. Customshouse in downtown Denver, but its conception goes back a long way.

Event worthy of recognition

Some of the earliest Reclamation research was done by J. Y. Jewett, who was employed from 1905-1917 and gathered samples for research work on concrete. By 1920, Jewett's work had led to the roots of what is now the concrete laboratory of the Engineering and Research Center.

The hydraulics laboratory was also tied to early Reclamation research with its Agricultural Experiment Station in Fort Collins, Colo., begun in 1930. By 1937, however, the concrete and hydraulics laboratories were firmly established in downtown Denver.

It was in this laboratory that special tests were conducted on ordinary portland cement to be used in the mass concrete construction of Hoover Dam. Until these investigations were completed, little was known regarding the properties of mass concrete in dam construction.

In 1946, the expanded workload of Reclamation caused the entire operation to move to the Remington Small Arms Plant, now the Denver Federal Center. The move enabled consolidation of the laboratory facilities, increased economy and effi-

Kim R. Bell, Student Writer-Editor Trainee, from Colorado State University, Public Affairs Service Center, Denver, Colo.

Commissioner of Reclamation Straus at the dedication ceremonies.

Main entrance through GRMCO tunnel to manufacturers' exhibits in background.

Audience and speakers' platform.

Trainees from Thailand on the Avenue of Nations.

ciency of operations, provided ground for outdoor laboratory space, and permitted the use of larger, more versatile equipment.

One piece of equipment installed in the Engineering Center became the star of the 2-day dedication and open house in 1950. Reclamation's new five-story-high hydraulic testing machine, which can exert pressures up to 5 million pounds, demonstrated its ability to break concrete and steel, as well as cracking an egg without breaking the yolk. The machine is still used by Reclamation.

"Actually, the affair might be called a Reclamation exposition," L. N. McClellan, Chief Engineer and official host, said. "We hope the people who own the dams, powerplants, and canals that make up the Reclamation system, will take this opportunity to see how they are built. They will find the display interesting, informative, and perhaps even inspiring."

Since the celebration had Denver's backing, Mayor Newton appointed a committee of private citizens to help with the arrangements. Two weeks prior to the dedication, models and photographs went on display at the Denver City and County Building. The city hall display included several models of dam construction as well as a model of a small diversion dam. The city hall exhibit moved to the Engineering Center several days before the dedication.

Concrete research led to laboratories

The day before the dedication, 600 guests were invited to a preview tour of the Engineering Center. These guests included representatives of Federal and State agencies, the sponsoring Denver committee, members of the water users' organization, as well as Colorado congressmen and several government officials from Washington.

Besides the formal ceremony, the Engineering Center sponsored an open house with over 300 displays and exhibits. For 2 days the public observed exhibits showing how dams operated in 17 Western States. They watched 2,000 engineers and technicians at work on designs for Reclamation projects. Hydraulic models showed how dams and spillways were tested on a miniature scale.

The second day of the dedication ceremonies was designated "International Day" in observance of the Bureau of Reclamation's service to foreign countries. The Engineering Center was decorated with flags,

Neusteter's department store window displaying gates and valves.

Governors from four States confer (l. to r.) George T. Mickelson, S. Dak., John W. Bonner, Mont., Fred Aandahl, N. Dak., Walter W. Johnson, Colo.

forming an avenue of nations. Capus Waynick, ambassador to Nicaragua, was the principal speaker.

Governor Walter Johnson summed up Colorado's feelings about the Center at the dedication. "...we in Colorado are proud to be the permanent home of this installation which in years to come will participate in and cooperate in the development of projects far reaching in their implications, and vital in their results."

Today, known as the Engineering and Research (E&R) Center, the facility consists of a high-rise building dedicated in 1967, building 56 that was dedicated in 1950 and now primarily houses the research laboratories, as well as building 53. The Center employs some 1,400 people in a variety of disciplines. In addition to engineering and research, it houses major Reclamation offices for administration, planning and operations, public affairs, and dam safety.

As Commissioner Straus put it at the dedication, "Of all the works Reclamation has brought into being, history may record this Center as the most important." ■

Chronology

1905 John Y. Jewett employed as "Cement expert at Denver, Colorado."
1920 Concrete laboratory formed, Denver.
1930 Hydraulics laboratory formed at Agricultural Experiment Station in Fort Collins, Colo.
1934 Hydraulics and Concrete laboratories maintained in U.S. Customshouse, Denver.
1946 Laboratories and offices moved from downtown Denver to Remington Small Arms Plant, now the Denver Federal Center.
1950 The Engineering Center (Bldg. 56) was formally dedicated.
1967 New high-rise, Building 67, at Engineering Center dedicated.
1970 Engineering Center became known as the Engineering and Research Center. ■

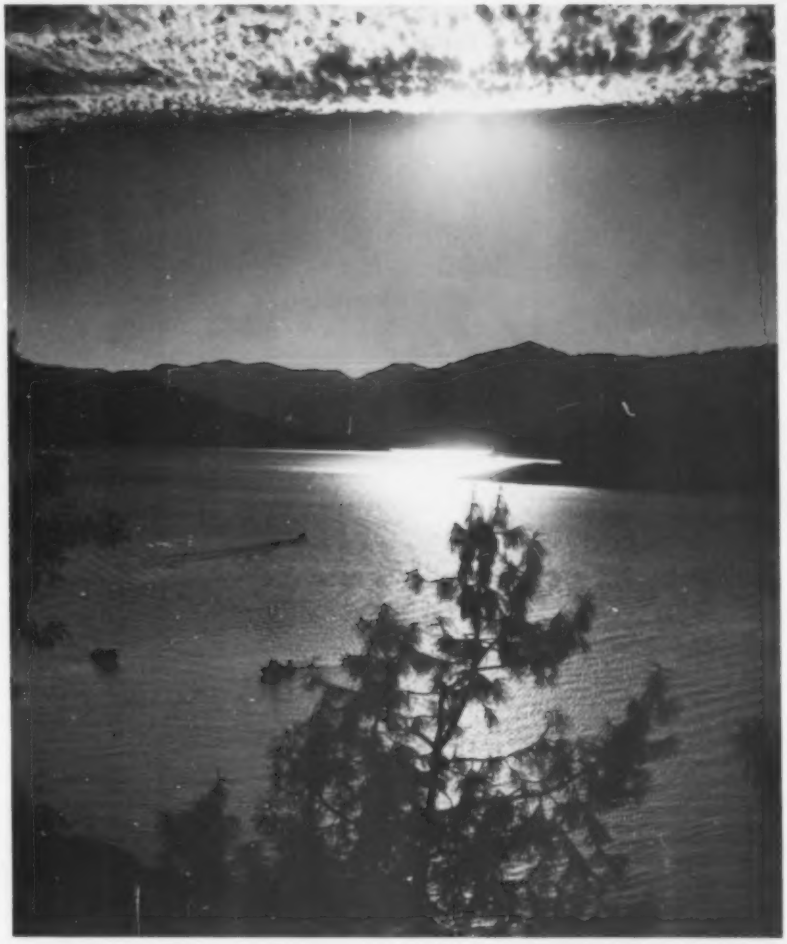
Water Quiz

1. A cubic foot of air can hold only so much water vapor at a given temperature; it is then said to be saturated. What happens if the temperature is increased?
a. it remains the same.
b. it cannot hold what it has.
c. it can absorb more.

2. The sun is the Earth's powerplant. All the food we eat, the fuel we burn, the power of winds and waters, all derive from the Sun. What percentage of the energy produced by the Sun actually strikes the Earth's surface?
a. 100%
b. 50%
c. 25%

3. Humans cannot drink ocean water because of its salinity. Can ocean ice, including icebergs, be melted and drunk? Yes or No.

4. Water vapor (clouds, fog, etc.) is the Earth's blanket. How does water vapor benefit life on Earth?



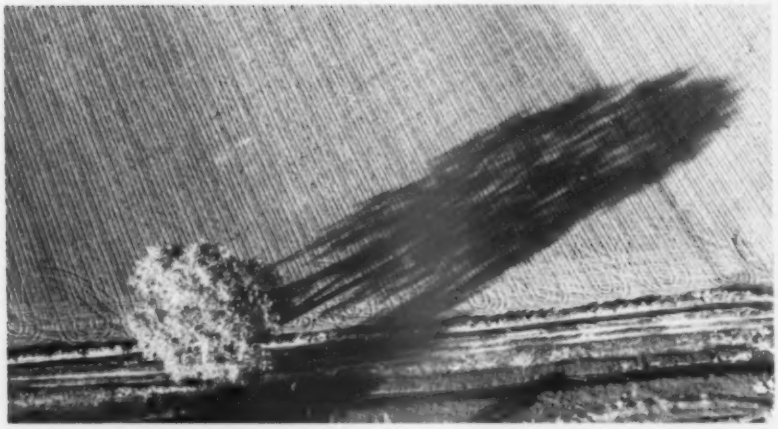
Answers to Water Quiz on page 36.

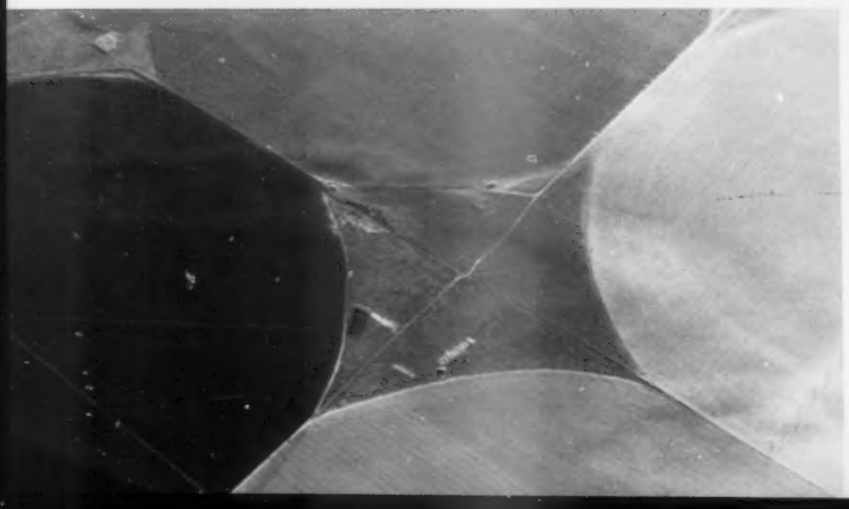
Centennial's Colorado Today

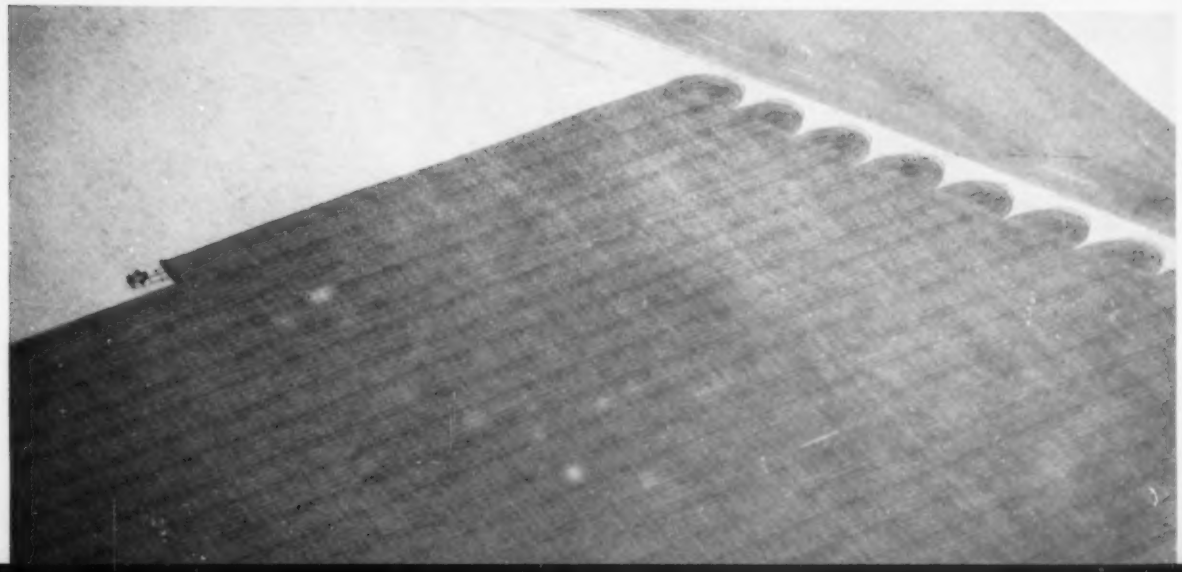
by Bob Pauline

"...purple mountain majesties above the fruited plains..." Unlike the words from Katherine Lee Bates' "America the Beautiful," most people remember the mountains and ignore the plains. However, the Great Plains of Colorado offer unique beauty and sustenance with more than 40,000 square miles of rich farmland.

Glimpses of life on these plains, vividly described in James Michener's *Centennial,* were captured in the early morning by Bob Pauline, Bureau's Photographic Coordinator, Denver, Colo. ■







Reclamation Library

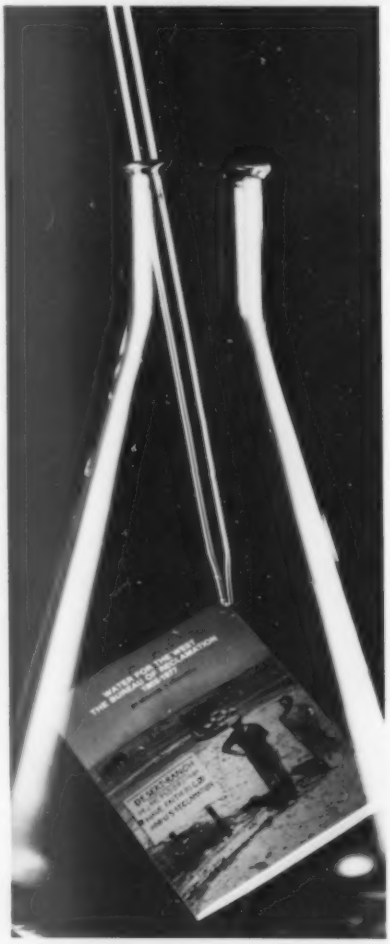
Reclamation beginnings and present-day trends are explored in Michael C. Robinson's new book, *Water For The West.* The book includes "Reclamation Origins," "The Irrigation Age, 1902-1927," "Multiple-Purpose Triumphs, 1928-1952," "Changing Times, 1953-1977," as well as sources of information and an index.

Water For The West is written in the matrix style. Each part forms a complete story which can be used as a guide and developed to greater detail for use in writing papers, theses, and dissertations.

As head of the Public Works Historical Society, Robinson searched the book while under contract to the Bureau of Reclamation.

The 109-page illustrated book can be purchased from the Public Works Historical Society, 1313 East 60th Street, Chicago, IL 60637 for $6.00 a copy. ■

Photography by Howard Paul, Engineering and Research Center, Denver, Colo.



Answers to Water Quiz

1. C, it can absorb more.

2. B, 50% (approximately 12 million billion horsepower).

3. Yes, only the water freezes; the salt is expelled, increasing the salinity of the surrounding water.

4. Water vapor, together with ozone, reflects a large portion of the Sun's short-wave radiation. If all the short-wave radiation striking the Earth's atmosphere reached the surface, there would be little or no life.

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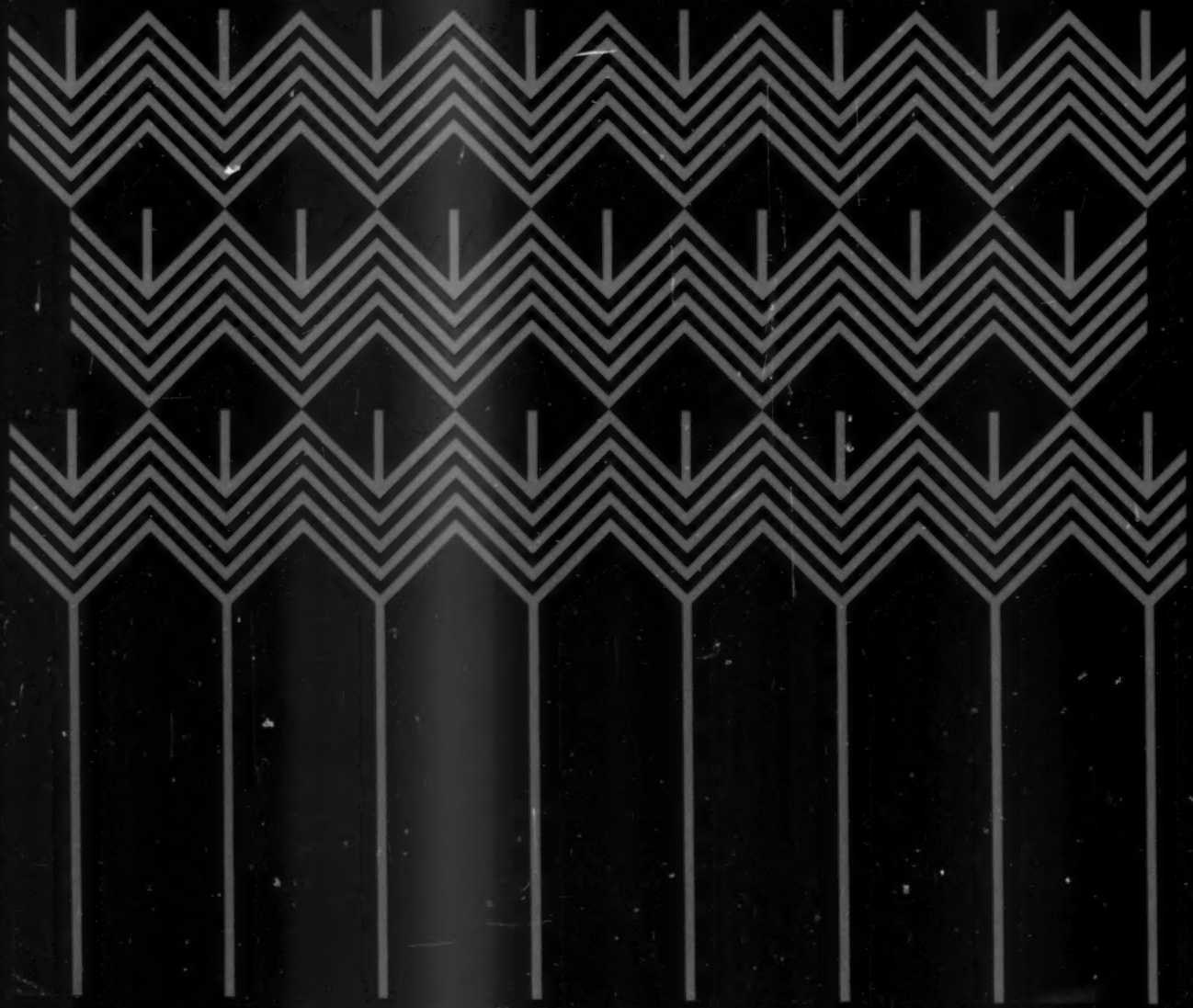
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